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CRYSTAL UNIT

BACKGROUND OF THE INVENTION:

1. Field of the Invention:

The present invention relates to a quartz crystal unit, and more particularly, to a crystal unit having an excellent vibration characteristic and small dispersion in quality.

2. Description of the Related Arts:

A surface mount crystal unit is widely used for an oscillator and the like as a reference source of frequency or time, especially in portable electronic devices since it is small and light. While miniaturization of a surface mount crystal unit is advancing more and more in recent years, the vibration characteristic of a crystal unit is required to be kept constant despite the miniaturization.

A conventional surface mount crystal unit shown in FIGS. 1A and 1B is realized by accommodating quartz crystal blank 2 in casing 1 made of laminated ceramics or the like, covering the opening of casing 1 with cover 3 and thereby hermetically sealing crystal blank 2 in casing 1. Casing 1 is suitable for surface mounting and provided with a recess having a substantially rectangular shape as a two-dimensional projected shape. A pair of connection terminals 4 used for an electrical connection with crystal blank 2 is provided at both sides of one end of the inner bottom surface of the recess. Connection terminals 4 are electrically connected to external terminals 5 provided on the outer surface of casing 1 via a conductive path (not shown) through the laminated plane of the laminated ceramics.

As shown in FIG. 2, crystal blank 2 has a substantially rectangular planar

shap , and linear or curved inclined surfaces are formed on both principal surfaces of the crystal blank at both ends in the longitudinal direction of crystal blank 2. That is, both principal surfaces have so-called beveled surfaces or convex surfaces at both longitudinal ends of crystal blank 2. Excitation electrodes 6 are formed on the flat areas of both principal surfaces of crystal blank 2 and extension electrodes 7 are drawn out from excitation electrodes 6 toward both sides of one end of crystal blank 2 across the surface of the inclined surface at the one end. Extension electrodes 7 are folded over the principal surface on the opposite side at the position of the end face of crystal blank 2. Both sides of one end of crystal blank 2 to which extension electrodes 7 are extended are fixed onto the pair of connection terminals 4 through a conductive material, for example, conductive adhesive 8, and then crystal blank 2 is electrically and mechanically connected to casing 1 and held in the recess of casing 1. Then, by placing cover 3 so as to cover the recess, crystal blank 2 is hermetically sealed in casing 1. A crystal unit with inclined surfaces formed at both ends of a crystal blank on both principal surfaces and the crystal blank fixed to a casing by means of a conductive adhesive is disclosed in Japanese Patent Application Laid-Open No. 2001-196886 (JP, P2001-196886A).

Here, the process of fixing crystal blank 2 will be explained. As shown in FIG. 3, conductive adhesive 8 is normally applied to connection terminals 4 and then both sides of one end of crystal blank 2 on which the inclined surface is formed are positioned under a pressure indicated by arrow P. Then the assembly of casing 1 and crystal blank 2 is heated. Crystal blank 2 is thus secured through heating and hardening of conductive adhesive 8.

In the crystal unit manufactured through such a process, because of the inclined surfaces provided at both ends of crystal blank 2, vibration energy is

trapped in th flat area in the cent r f crystal blank 2 and the vibration characteristic represented by crystal impedance (CI), etc., is thereby maintained satisfactorily.

However, the surface mount crystal unit in the above described conventional configuration has the following problems because the inclined surfaces of the crystal blank are fixed by means of conductive adhesive 8. That is, since both sides at one end of the inclined surface is pressed and then heated, the pressing force and pressing direction of the pressure applied to conductive adhesive 8 vary from one crystal blank to another depending on factors such as the positioning accuracy of the crystal blank. With such variations in the pressing force and pressing direction, the holding state and holding system also vary from one crystal blank 2 to another, causing variations in the holding state and thereby producing also non-uniformity in the vibration characteristic as the crystal unit. Furthermore, conductive adhesive 8 may wrap around from the inclined surface at the end of crystal blank 2 up to the flat area which is the vibration area and may deteriorate the vibration characteristic of the crystal unit as a consequence. These problems become noticeable because the influence of holding crystal blank 2 increases as the miniaturization of crystal blank 2 advances.

In the case of a crystal unit in a configuration with a crystal blank inserted between clamp type metal holding members, the configuration with inclined surfaces provided at both ends of one or both principal surfaces of the crystal blank is disclosed, for example, in Japanese Utility Model Application Laid-Open No. 61-70425 (JP, 61-70425, U).

SUMMARY OF THE INVENTION:

It is an object of the present invention to provide a crystal unit whose

vibration characteristic is maintained satisfactorily and has of stable quality.

The object of the present invention is attained by a crystal unit comprising a crystal blank provided with a pair of excitation electrodes and a pair of extension electrodes extended from the excitation electrodes, and a mounting member having a pair of connection terminals, wherein the crystal blank includes a first principal surface and a second principal surface, an inclined surface is formed at one end of the first principal surface, the second principal surface is flat-shaped, extension electrodes are extended toward the end at which the inclined surface is formed, and a conductive material is disposed between the connection terminals and the extension electrodes in such a way that the second principal surface faces the mounting member and the crystal blank is held by the mounting member at the position of the end to which the extension electrodes are extended and electrically connected to the connection terminals.

According to the present invention, when the crystal blank is fixed to the mounting member, the flat area of the crystal blank contacts the conductive material represented by the conductive adhesive. This allows pressing conditions such as the pressing force and pressing direction of a pressure applied to the crystal blank and conductive material to be controlled so that they are kept constant, and the crystal blank can be held uniformly and the quality of the finished crystal unit can also be stabilized. It further prevents a conductive adhesive or the like from wrapping around up to the vibration area of the crystal blank and keeps the vibration characteristic satisfactorily.

In the present invention, the mounting member is typically a casing suitable for surface mounting. This casing includes a recess and is provided with a pair of connection terminals on the bottom face of the recess. When

such a casing is used, the crystal blank is fixed to the connection terminals, and then a cover is placed so as to cover the recess and in this way the crystal blank is hermetically sealed in the casing and the crystal unit is completed.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIG. 1A is a sectional view showing an example of a conventional surface mount crystal unit;

FIG. 1B is a plan view of the crystal unit shown in FIG. 1A with the cover removed;

FIG. 2 is a plan view showing an example of a crystal blank;

FIG. 3 is an enlarged partial view of the crystal unit shown in FIG. 1A;

FIG. 4 is a sectional view of a surface mount crystal unit according to an embodiment of the present invention;

FIG. 5 is a perspective view of a crystal blank used in the crystal unit shown in FIG. 4;

FIG. 6 is an enlarged partial view of the crystal unit shown in FIG. 4;

FIG. 7 is a perspective view showing another example of the crystal blank; and

FIG. 8 is a perspective view showing a further example of the crystal blank.

DETAILED DESCRIPTION OF THE INVENTION:

As in the case of the quartz crystal unit shown in FIGS. 1A and 1B, the crystal unit according to an embodiment of the present invention shown in FIG. 4 is realized by accommodating quartz crystal blank 2 in casing 1 made of laminated ceramics, covering the opening of casing 1 with cover 3 and thereby hermetically sealing crystal blank 2 in casing 1. As casing 1 used as the mounting member, a casing similar to that shown in FIGS. 1A and 1B is used, a

pair of connection terminals 4 is provided on th bottom face of a recess of casing 1 and external terminals 5 electrically connected to connection terminals 4 are provided on the outer surface of casing 1.

As shown in FIG. 5, crystal blank 2 has a substantially rectangular shape as a two-dimensional projected shape and comprises, for example, an AT-cut quartz crystal blank. An AT-cut quartz crystal blank has a vibration mode by thickness-shear vibration. Crystal blank 2 has a first principal surface and a second principal surface, and linear inclined surface are formed on the first principal surface as beveled surfaces at both ends in the longitudinal direction of crystal blank 2. The second principal surface of crystal blank 2 is provided with no such inclined surface and is flat-shaped. Excitation electrode 6 is formed on the flat area of the first principal surface and another excitation electrode 6 is also formed on the second principal surface in such a way as to face excitation electrode 6 on the first principal surface. From these excitation electrodes 6, extension electrodes 7 are extended or drawn out toward both sides at one end of crystal blank 2. Extension electrodes 7 are formed in such a way that they are folded over the opposite principal surface at the tip end of crystal blank 2.

Crystal blank 2 is placed in such a way that the second principal surface of crystal blank 2 faces the bottom face of the recess of casing 1 and both sides at one end of crystal blank 2 toward which extension electrodes 7 are extended are fixed onto connection terminals 4 by means of conductive adhesive 8, and thereby electrically and mechanically connected to casing 1 and held level in the recess of casing 1. When crystal blank 2 is fixed, conductive adhesive 8 is applied to connection terminals 4 first, and then crystal blank 2 is positioned in such a way that the second principal surface faces down and both sides at one

end of crystal blank 2 are placed on top of conductive adhesive 8 under a pressure indicated by arrow P in the figure. Then the assembly of casing 1 and crystal blank 2 is heated to harden conductive adhesive 8. Then, cover 3 is provided so as to cover the recess of casing 1 and in this way the crystal unit is completed.

In such a configuration, conductive adhesive 8 applied to connection terminals 4 receives a pressing force from the flat surface of crystal blank 2 as shown in FIG. 6. Therefore, even if some deviation occurs when crystal blank 2 is positioned, the pressing force acts on conductive adhesive 8 in substantially the same direction and uniformly. This makes uniform the state in which crystal blank 2 is held for each crystal unit, reducing variations in the quality of the finished crystal unit. It also prevents conductive adhesive 8 from wrapping around up to the vibration area of crystal blank 2 and makes it possible to keep a good vibration characteristic.

Here, an example of the actually created crystal unit according to this embodiment will be explained. As the crystal blank, an AT-cut quartz crystal blank was used and made into approximately 1.5 mm × 1.1 mm in size and its vibration frequency was set to 20 MHz. The thickness of the crystal blank in the vibration area is approximately 0.084 mm. Furthermore, length L of the inclined surface from the end of the crystal blank was set to 0.4 mm and thickness T at the end face of the inclined surface was set to 0.04 mm. Then, a conventional crystal blanks with inclined surfaces provided on both principal surfaces and the crystal blanks according to this embodiment were prepared and fixed to the respective casings and compared. As a result, the crystal blanks according to this embodiment showed a stable CI value of 30 Ω. On the contrary, when a good product was selected from among the conventional

crystal blanks, a CI value of 30 Ω was obtained but its characteristic varied drastically from one crystal unit to another. From these results, it is evident that the present invention can provide a crystal unit whose vibration characteristic is maintained satisfactorily and of stable quality.

In this embodiment, the crystal blank is fixed and held with both sides at one end in the longitudinal direction of crystal blank 2, and therefore when mechanical shock is applied to the crystal blank, there is a danger that the other end of the crystal blank may collide with the bottom face of the recess of casing 1. In this case, since the underside of the crystal blank, that is, the second principal surface is flat-shaped, it is the tip at the other end and not the vibration area that collides with the bottom face of the recess. On the contrary, when inclined surfaces are formed on both principal surfaces as in the case of the conventional example, there is a danger that instead of part of the inclined surface at the other end colliding with the bottom face of the recess, the vibration area of a greater thickness may collide with the bottom face of the recess. From the standpoint of influences when mechanical shock is applied, the crystal unit according to this embodiment is more advantageous.

The crystal unit according to one embodiment of the present invention has been explained above, but the crystal blank usable for the present invention is not limited to the above described one. The crystal blank shown in FIG. 7 is one provided with an inclined surface at only one end in the longitudinal direction of crystal blank 2. No inclined surface is provided at the other end of crystal blank. In this case, too, the inclined surface is only provided on the first principal surface and the second principal surface is flat-shaped. Extension electrodes 7 are extended toward both sides at the end at which the inclined surface is provided. In this case, an effect similar to that described above can

be obtained by fixing the crystal blank in such a way that the flat surface i.e., the second principal surface faces down at the end toward which extension electrodes 7 are extended.

The crystal blank shown in FIG. 8 is one with inclined surfaces provided at both ends of crystal blank 2, but the inclined surfaces are different from each other in size at the two ends. By providing the inclined surfaces at both ends, it is possible to enhance the trapping effect of vibration energy. In this case, extension electrodes 7 are extended toward the end having the greater inclined surface and crystal blank 2 is fixed at this end.

Furthermore, the present invention can also be adapted in such a way that the extension electrodes are extended, respectively, toward both ends in the longitudinal direction of the crystal blank. In this case, the crystal can be fixed to the case at both ends.

In the present invention, the shape of the inclined surfaces is not limited to a linear shape. For example, the inclined surfaces may also be finished to a curved shape. The ridge angle section of crystal blank 2 may be subjected to deburring using a barrel, etc., so as to take on roundness.

As the conductive material to electrically and mechanically connect the crystal blank to the connection terminals, it is also possible to use, for example, a eutectic alloy or bump instead of using a conductive adhesive. Furthermore, the mounting member to which the crystal blank is fixed is not limited to a recessed casing, but may also be a flat-shaped mounting member.